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THE PHYSICAL PROPERTIES OF DEEP CRUSTAL ROCKS.(U)
MAR 81 G SIMMONS, L BALES, L CARUSO, H COOPER N00014-76-C-0478
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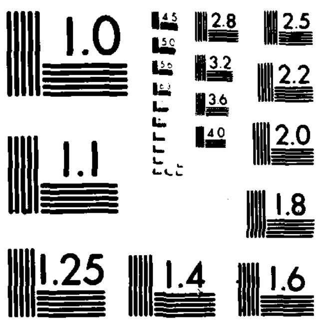

MICROCOPY RESOLUTION TEST CHART
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on

(6) THE PHYSICAL PROPERTIES OF DEEP CRUSTAL ROCKS.

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(12) 11 (15)

Contract Number: N00014-76-C-0478

Period: 1 July 1975 through 31 December 1980

Submitted: (11) 1 March 1981

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INTRODUCTION

The work accomplished in this project during the period 1 July 1975 through 31 December 1980 has been reported at scientific meetings and in various publications. Citations of the oral presentations are given in Table 1. Citations of the published papers are given in Table 2. The highlights are described briefly in the next section.

Table 1.
Oral Presentations

Authors	Title	Year	Meeting Where Presented
Simmons, Richter, Siegfried, and Feves	Microcracks in ancient rocks	1976	American Geophysical Union Annual Spring Meeting
Wang and Simmons	Laboratory and *in situ* velocities from a deep well in the Michigan Basin	1976	American Geophysical Union Annual Spring Meeting
Feves and Simmons	The relationship of micro-cracks to *in situ* stress in southeastern Missouri	1976	Geological Society of America Annual Meeting
Feves and Simmons	The relationship of pre-existing cracks to stress induced cracks in rocks	1977	American Geophysical Union Annual Spring Meeting
Fehler and Simmons	Depth dependence and origin of microcracks in granitic rock from Casco, Maine	1978	American Geophysical Union Annual Spring Meeting
Shirey, Simmons, and Padovani	Angular, oriented micro-tubes in metamorphic oligoclase	1979	American Geophysical Union Annual Spring Meeting
Padovani, Shirey, and Simmons	Microcracks and amphibolite and granulite facies grade rocks from southeastern Pennsylvania	1979	American Geophysical Union Annual Spring Meeting

Table 2.
Published Reports

Authors	Title	Year	Where Published	Comment
Simmons, Siegfried, and Feves	Differential strain analysis: A new method for examining cracks in rocks	1974	Journal of Geophysical Research, 79, 4383-4385	ONR support
Feves and Simmons	Effects of stress on cracks in Westerly granite	1976	Bulletin of the Seismological Society of America, 66, 1755-1765	partial ONR support
Feves, Simmons, and Siegfried	Microcracks in crustal igneous rocks: Physical properties	1977	The Earth's Crust: Its Nature and Physical Properties, AGU, 95-117	ONR support
Richter and Simmons	Microcracks in crustal igneous rocks: Microscopy	1977	The Earth's Crust: Its Nature and Physical Properties, AGU, 149-180	ONR support
Bales	Fracture state of the Marcy Massif anorthosite at Saranac Lake, New York as characterized by physical properties	1977	B.A. thesis, Wellesley College	ONR support
Siegfried and Simmons	Characterization of oriented cracks with differential strain analysis	1978	Journal of Geophysical Research, 83, 1269-1278	ONR/NASA support

Table 2 (continued).

Authors	Title	Year	Where Published	Comment
Simmons and Cooper	Thermal cycling cracks in three igneous rocks	1978	International Journal of Rock Mechanics and Mining Science and Geomechanical Abstracts, 15, 145-148	ONR support
Wang and Simmons	Microcracks in crystalline rock from 5.3-km depth in the Michigan Basin	1978	Journal of Geophysical Research, 83, 5849-5856	ONR/NSF support
Shirey, Simmons, and Padovani	Angular, oriented microtubes in metamorphic plagioclase	1980	Geology, 8, 240-244	ONR support
Simmons and Miller	Velocity of elastic waves as a predictor of electrical conductivity for rocks	1980	Technical Report to ONR	ONR support
Simmons and Caruso	Petrography of several metamorphic rocks to be used for measurement of physical properties	1980	Technical Report to ONR	ONR support
Simmons, Caruso, and Miller	Complex dielectric properties of several igneous and metamorphic rocks	1980	Technical report to ONR	ONR support
Simmons, Caruso, and Miller	The electrical conductivity of the crust of the eastern United States	1980	Technical Report to ONR	ONR support

Table 2 (continued).

Authors	Title	Year	Where Published	Comment
Fehler and Simmons	Microcracks in granitic rock from Casco, Maine	1981	In revision	ONR support
Padovani, Shirey, and Simmons	Characteristics of microcracks in amphibolite and granulite facies grade rocks from southeastern Pennsylvania	1981	In preparation	ONR support

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HIGHLIGHTS

Several results of the project stand out.

First, the DSA technique ~~(Simmons et al., 1974 and Siegfried and Simmons, 1978)~~ provides an important method of characterizing microcracks. It is presently being used by others. The Dowell Company appears to be developing industrial applications (Strickland and Ren, 1980a and b; Strickland et al., 1979).

Second, a suite of rocks with crack porosity that varies from less than ~~2 x 10^-6~~ to ~~1000 x 10^-6~~ has been identified ~~(Feves and Simmons, 1976)~~. The microcracks were characterized with DSA and further with the SEM and with the optical microscope ~~(Richter and Simmons, 1977)~~. This suite provides an important resource for the study of physical properties and their relations to microcracks.

Third, a technique was developed for the production of microcracks in rocks under controlled conditions. Simmons and Cooper (1978) showed that thermal cycling of rocks at low rates produces cracks of particular characteristics and that the volume of cracks depends on the maximum temperature used. Thus, we can now produce suites of rocks in the laboratory in which the only variable is the volume of microcracks.

Fourth, techniques for preparing specimens for examination of microcracks in the SEM were developed (with partial support from ONR). The techniques allow one to prepare samples without creating new microcracks in them. They were described initially by Richter and Simmons (1977) and have continued to evolve.

Fifth, empirical relations were developed for several pairs of physical properties. Feves et al. (1977) showed that electrical

resistivity, at low frequency, is related to crack porosity. Simmons and Miller (1980) showed that the velocities of elastic waves are related to the electrical conductivity (for igneous and metamorphic rocks). The potential applications of these relationships include estimates of crustal electrical conductivity from measured seismic velocities, site evaluation for waste disposal (including radioactive waste), and the estimation of porosity for igneous and metamorphic rocks from borehole logs of acoustic velocity.

Sixth, new measurements of the complex dielectric properties of several igneous and metamorphic rocks, under simulated crustal conditions ~~(Simmons et al., 1980a)~~, provided the data necessary to estimate the electrical properties of the crust of the eastern United States ~~(Simmons et al., 1980b)~~. The result is that the crust appears to be more resistive than believed previously. The new models permit the propagation of EM waves, at frequencies of 100-50,000 Hertz, to significant distances (100's km). The (vertical) electrical conductivity structure of the crust now appears to be suitable for communication via EM waves propagated through the lithosphere.

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